Journal of Physics Special Topics
An undergraduate physics journal

P4_5 Star Wars: Han's Solo Journey

H. Graham, S. Howard-Clark, W. Sainty, S. Kneeshaw

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

November 6, 2017

Abstract

The Star Wars saga has its fair share of impossible feats being performed on a regular basis throughout the films. In this paper we calculated how long the infamous Kessel Run would take Han Solo in the Millennium Falcon from his perspective at a velocity of 99% of the speed of light, and the perspective of an observer watching his journey unfold. We calculated his journey would take almost 40 years from the reference frame of an observer but would appear to only take 5.6 years from Han Solo's reference frame. The length contraction of the Falcon is also calculated and an observer in the galaxy would see the Falcon to be a mere 4.9 m long, 14% of its original size.

Introduction

In Stars Wars: A New Hope, Han Solo says that his ship, the Millennium Falcon (MF), performed the Kessel run (a smuggling operation between two destinations using gravitational assists around black holes) over 12 parsecs. We are going to investigate how long the Kessel Run took from Han's perspective, using 12 parsecs as his travel distance, and how travelling around black holes affects his view of the journey. Using calculations for length contraction and time dilation, we shall calculate how long the journey took in Han's reference frame when compared with how long the journey took at a velocity of $0.99c$ from the reference frame of an observer.

Theory

The Millennium Falcon is a Corellian YT-1300f Freighter, used in the Star Wars films by Han Solo for smuggling illegal goods and helping the Rebel Alliance in multiple battles against the Galactic Empire. When stationary, it has a length of 34.75 m [1]. In Star Wars: A New Hope, Han claims that he travelled in the MF at 1.5 times the speed of light, and managed to perform the Kessel Run over a distance of 12 parsecs, which equates to 3.7×10^{14} km [2] or 2.5 million times the distance between the Sun and Earth.

It is physically impossible to travel faster than the speed of light, as proven in Einstein's Theory of Relativity. Therefore we shall assume a more reasonable speed for the MF of $0.99c$ and briefly explore what would happen to Han's time if he travelled near black holes at such a high velocity. For an observer watching him approach a black hole, they would see a clock on the MF tick slower and slower as he got closer to the event horizon, whereas time would pass normally for Han and he would see no adverse effects. If Han got too close to the black hole he would be ripped apart by the gravitational force it exerts on the MF, but all an observer would see is Han frozen on the edge. They would perceive his time to have stopped, and take an infinite amount of time to cross the event horizon.

The relativistic effect of length contraction would also affect how the observer would view the MF near black holes. Not only would Han appear to have stopped on the event horizon, but the MF would start growing longer again in an effect called spaghettification. This is because the observer cannot see Han fall into the black hole, giving the impression that he is just stretching for an infinite amount of time due to the black hole's gravitational forces.

To calculate the true relativistic effects of Han's journey due to near light-speed travel, we will use the standard formula for time dilation (1) and length contraction (3) to calculate a more realistic version of Han's journey.

We shall use the equation for time dilation [3] given below to show how Han's journey time changes when he travels at $0.99c$:

$$t' = \gamma t, \tag{1}$$

where t' is the time that the stationary observer thinks Han is away for, t is the time in Han's reference frame he thinks he is away for, and the Lorentz factor (γ) expands to:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{2}$$

where c is the speed of light and v is the speed that Han is travelling at.

Equation (3) for relativistic length contraction [3] is used to determine how long the MF appears to the stationary observer when Han travels away through spacetime:

$$L' = \frac{L}{\gamma} \tag{3}$$

where L' is the stationary observer's perspective of the length of the MF, L is the length of the MF from Han's perspective (34.75 m), and the Lorentz factor (γ) given by equation (2).

Results

For equations (1) and (2), we take v equal to $0.99c$ and t' as 40 years. This value is derived from converting 12 parsecs to 39.2 light years [2], and then approximating light as taking 40 years to travel this distance (rounded up from 39.2 years). Using these values, Han would be away for a total of 5.6 years from his perspective. This would make him approximately 35 years younger than everybody else observing the journey when he arrived back at the cantina on Tatooine.

Furthermore, using the value of γ when v equals $0.99c$ gives a value for L' as 4.9 m from equation (3). This means that the stationary observer sees the MF shrink to just 14% of its original size (which is 34.75 m and is how Han perceives the size of the MF while on board).

Conclusion

Travelling at a velocity close to the speed of light has a severe effect on how long your journey time and ship appear to both you and an observer. In this instance, Han Solo's Kessel run takes almost 35 years less from his perspective than it does from the external observer's reference frame. This means there would be a significant difference between Han's age and the people he left behind. He would appear to be approximately 35 years younger than them. Overall, this has consequences on the timeline of the Star Wars films.

References

[1] `https://en.wikipedia.org/wiki/Millennium_Falcon` [Accessed 19 October 2017]

[2] `http://www.metric-conversions.org/length/` [Accessed 19 October 2017]

[3] Paul A. Tipler, G. M. (1999). Physics for Scientists and Engineers (6th ed.) New York. W.H. Freeman.